

# EXEMPLAR SOLUTIONS PHYSICS

Class  
**11**



Powered by



## Chapter 3 - Motion In A Plane

### Multiple Choice Questions I

$$A = \hat{i} + \hat{j} \quad \text{and} \quad B = \hat{i} - \hat{j} \quad \text{is}$$

4.1. The angle between

- a)  $40^\circ$
- b)  $90^\circ$
- c)  $-45^\circ$
- d)  $180^\circ$

Answer:

The correct answer is b)  $90^\circ$

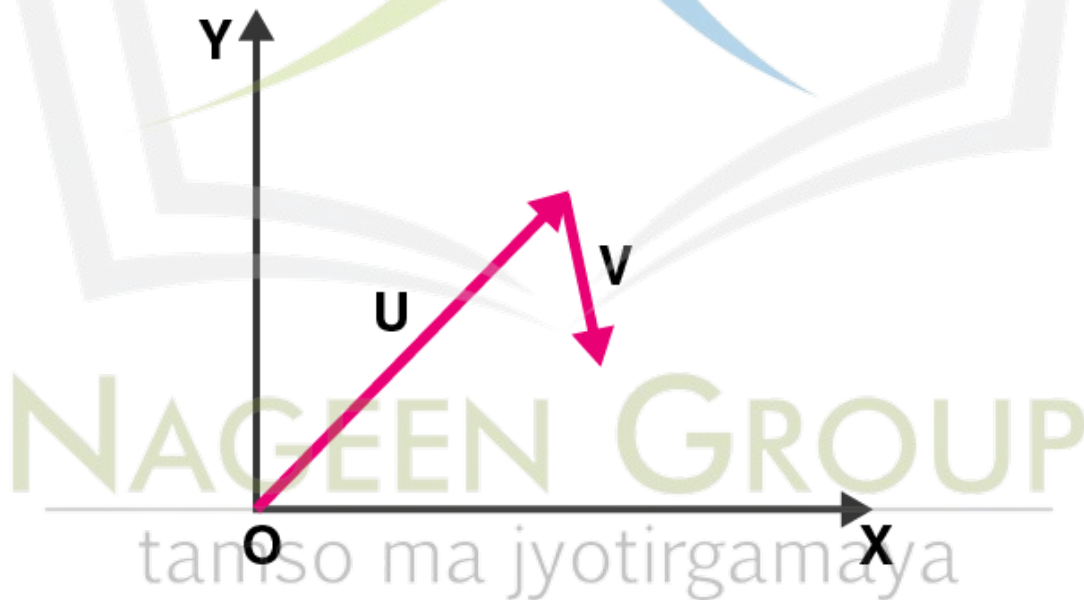
4.2. Which one of the following statements is true?

- a) a scalar quantity is the one that is conserved in a process
- b) a scalar quantity is the one that can never take negative values
- c) a scalar quantity is the one that does not vary from one point to another in space
- d) a scalar quantity has the same value for observers with different orientations of the axes

Answer:

The correct answer is d) a scalar quantity has the same value for observers with different orientations of the axes

4.3. Figure shows the orientation of two vectors  $u$  and  $v$  in the  $XY$  plane.



If  $u = a\hat{i} + b\hat{j}$  and  $v = p\hat{i} + q\hat{j}$  which of the following is correct?

- a)  $a$  and  $p$  are positive while  $b$  and  $q$  are negative
- b)  $a$ ,  $p$ , and  $b$  are positive while  $q$  is negative
- c)  $a$ ,  $q$ , and  $b$  are positive while  $p$  is negative
- d)  $a$ ,  $b$ ,  $p$ , and  $q$  are all positive

Answer:

The correct answer is b)  $a$ ,  $p$ , and  $b$  are positive while  $q$  is negative



4.4. The component of a vector  $r$  along X-axis will have maximum value if

- a)  $r$  is along positive Y-axis
- b)  $r$  is along positive X-axis
- c)  $r$  makes an angle of  $45^\circ$  with the X-axis
- d)  $r$  is along negative Y-axis

Answer:

The correct answer is b)  $r$  is along positive X-axis

4.5. The horizontal range of a projectile fired at an angle of  $15^\circ$  is 50 m. If it is fired with the same speed at an angle of  $45^\circ$ , its range will be

- a) 60 m
- b) 71 m
- c) 100 m
- d) 141 m

Answer:

The correct answer is c) 100 m

4.6. Consider the quantities pressure, power, energy, impulse, gravitational potential, electric charge, temperature, area. Out of these, the only vector quantities are

- a) impulse, pressure, and area
- b) impulse and area
- c) area and gravitational potential
- d) impulse and pressure

Answer:

The correct answer is b) impulse and area

4.7. In a two dimensional motion, instantaneous speed  $v_0$  is a positive constant. Then which of the following are necessarily true?

- a) the average velocity is not zero at any time
- b) average acceleration must always vanish
- c) displacements in equal time intervals are equal
- d) equal path lengths are traversed in equal intervals

Answer:

The correct answer is d) equal path lengths are traversed in equal intervals

4.8. In a two dimensional motion, instantaneous speed  $v_0$  is a positive constant. Then which of the following are necessarily true?

- a) the acceleration of the particle is zero
- b) the acceleration of the particle is bounded
- c) the acceleration of the particle is necessarily in the plane of motion
- d) the particle must be undergoing a uniform circular motion

Answer:

The correct answer is d) the particle must be undergoing a uniform circular motion

4.9. Three vectors  $A$ ,  $B$ , and  $C$  add up to zero. Find which is false

- a) vector  $(A \times B) \cdot C$  is not zero unless vectors  $B$ ,  $C$  are parallel
- d) vector  $(A \times B) \cdot C$  is not zero unless vectors  $B$ ,  $C$  are parallel
- c) if vectors  $A$ ,  $B$ ,  $C$  define a plane,  $(A \times B) \cdot C$  is in that plane

d)  $(A \times B) \cdot C =$

$$|A||B||C|$$

such that  $C^2 = A^2 + B^2$

**Answer:**

The correct answer is c) if vectors A, B, C define a plane,  $(A \times B) \cdot C$  is in that plane and d)  $(A \times B) \cdot C =$

$$|A| |B| |C|$$

such that  $C^2 = A^2 + B^2$

4.10. It is found that  $|A + B| = |A|$ . This necessarily implies

- a)  $B = 0$
- b) A, B are antiparallel
- c) A, B are perpendicular
- d)  $A \cdot B \leq 0$

**Answer:**

The correct answer is a)  $B = 0$

## Multiple Choice Questions II

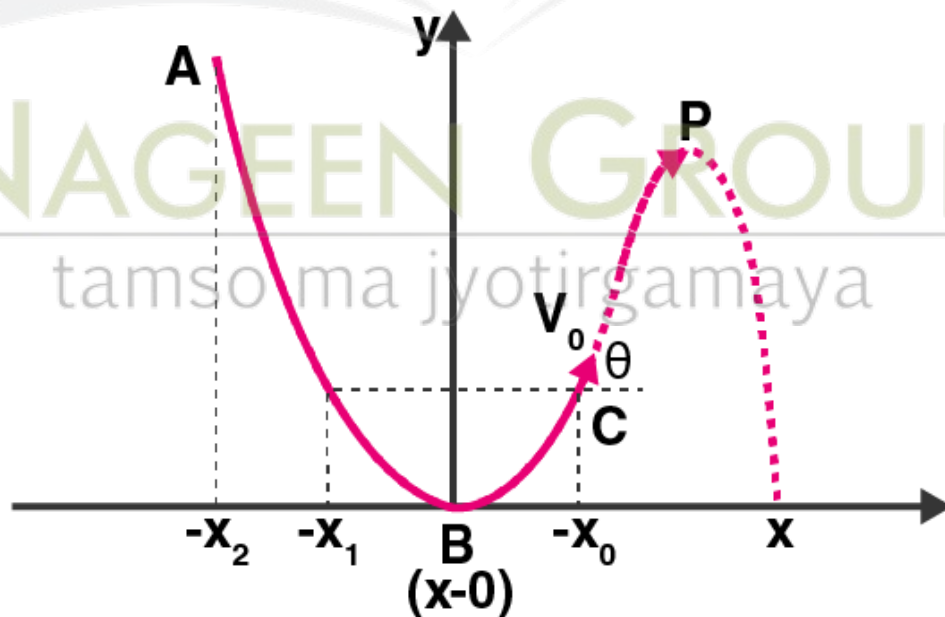
4.11. Two particles are projected in air with speed  $v_0$ , at angles  $\theta_1$  and  $\theta_2$  to the horizontal, respectively. If the height reached by the first particle is greater than that of the second, then tick the right choices

- a) angle of project:  $\theta_1 > \theta_2$
- b) time of flight:  $T_1 > T_2$
- c) horizontal range:  $R_1 > R_2$
- d) total energy:  $U_1 > U_2$

**Answer:**

The correct answer is a) angle of project:  $\theta_1 > \theta_2$  and b) time of flight:  $T_1 > T_2$

4.12. A particle slides down a frictionless parabolic track starting from rest at point A. Point B is at the vertex of parabola and point C is at a height less than that of point A. After C, the particle moves freely in air as a projectile. If the particle reaches highest point at P, then



- a) KE at P = KE at B
- b) height at P = height at A
- c) total energy at P = total energy at A
- d) time of travel from A to B = time of travel from B to P

**Answer:**

The correct answer is c) total energy at P = total energy at A

**4.13. Following are four different relations about displacement, velocity, and acceleration for the motion of a particle in general. Choose the incorrect one (s):**

- a)  $v_{av} = 1/2 [v(t_1) + v(t_2)]$
- b)  $v_{av} = r(t_2) - r(t_1) / t_2 - t_1$
- c)  $r = 1/2 [v(t_2) - v(t_1)](t_2 - t_1)$
- d)  $a_{av} = v(t_2) - v(t_1) / t_2 - t_1$

**Answer:**

The correct answer is a)  $v_{av} = 1/2 [v(t_1) + v(t_2)]$  and c)  $r = 1/2 [v(t_2) - v(t_1)](t_2 - t_1)$

**4.14. For a particle performing uniform circular motion, choose the correct statement from the following:**

- a) magnitude of particle velocity (speed) remains constant
- b) particle velocity remains directed perpendicular to radius vector
- c) direction of acceleration keeps changing as particle moves
- d) angular momentum is constant in magnitude but direction keep changing

**Answer:**

The correct answer is a) magnitude of particle velocity (speed) remains constant, b) particle velocity remains directed perpendicular to radius vector and c) direction of acceleration keeps changing as particle moves

**4.15. For two vectors A and B,  $|A + B| = |A - B|$  is always true when**

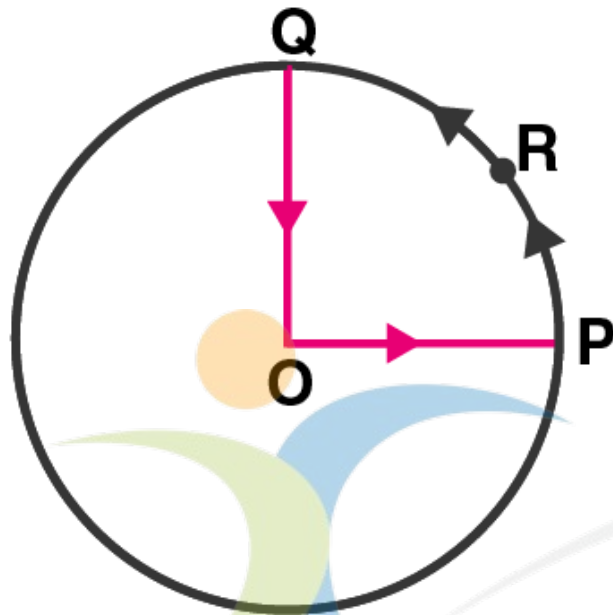
- a)  $|A| = |B| \neq 0$
- b)  $A \perp B$
- c)  $|A| = |B| \neq 0$  and A and B are parallel or antiparallel
- d) when either  $|A|$  or  $|B|$  is zero

**Answer:**

The correct answer is b)  $A \perp B$  and d) when either  $|A|$  or  $|B|$  is zero

### Very Short Answers

**4.16. A cyclist starts from centre O of a circular park of radius 1 km and moves along the path OPRQO as shown in the figure. If he maintains constant speed of 10 m/s, what is his acceleration at point R in magnitude and direction?**



**Answer:**

The radius of the circular path is 1 km with O as the centre and at distance R.

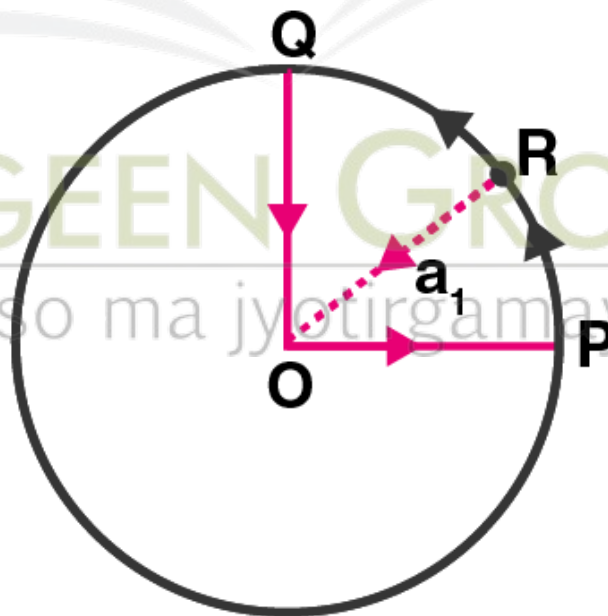
Speed with which the cyclist is moving is 10 m/s.

Therefore, it can be said that the motion is uniform circular motion at R.

Therefore,  $R = 1000 \text{ m}$

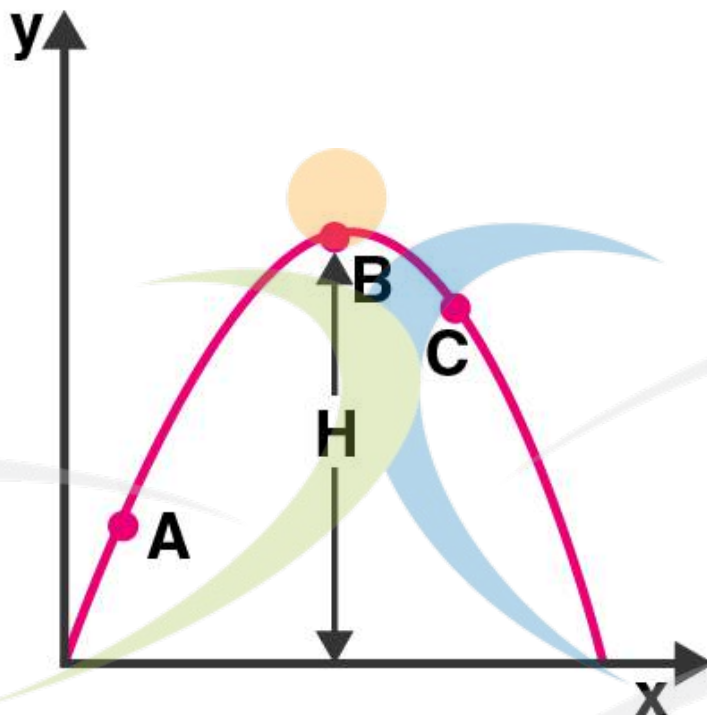
$v = 10 \text{ m/s}$

Therefore, acceleration,  $a_c = v^2/R = 0.1 \text{ m/s}^2$  along RO.



NAGEEN GROUP  
tamso ma jyotirgamaya

4.17. A particle is projected in air at some angle to the horizontal, moves along parabola as shown in the figure, where x and y indicate horizontal and vertical directions respectively. Show in the diagram, direction of velocity and acceleration at points A, B, and C.

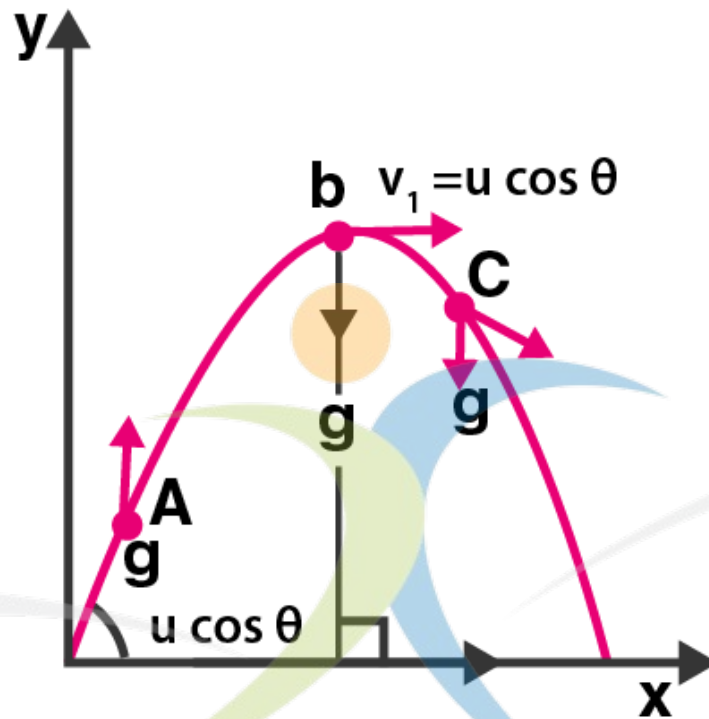


**Answer:**

The projectile motion is either parabolic or part of it. The velocity is always tangential to the direction of velocities of A, B and C. At point B, the maximum height is reached by the trajectory. Therefore, the vertical component  $Bv_y = 0$  and horizontal component is  $u \cos \theta$ .

We know that the direction of acceleration is in the direction of force acting on the body. Therefore, here the direction of acceleration is in the direction of gravitational force and is always vertically downward which is equal to the acceleration due to gravity.





**4.18. A ball is thrown from a roof top at an angle of  $45^\circ$  above the horizontal. It hits the ground a few seconds later. At what point during its motion, does the ball have**

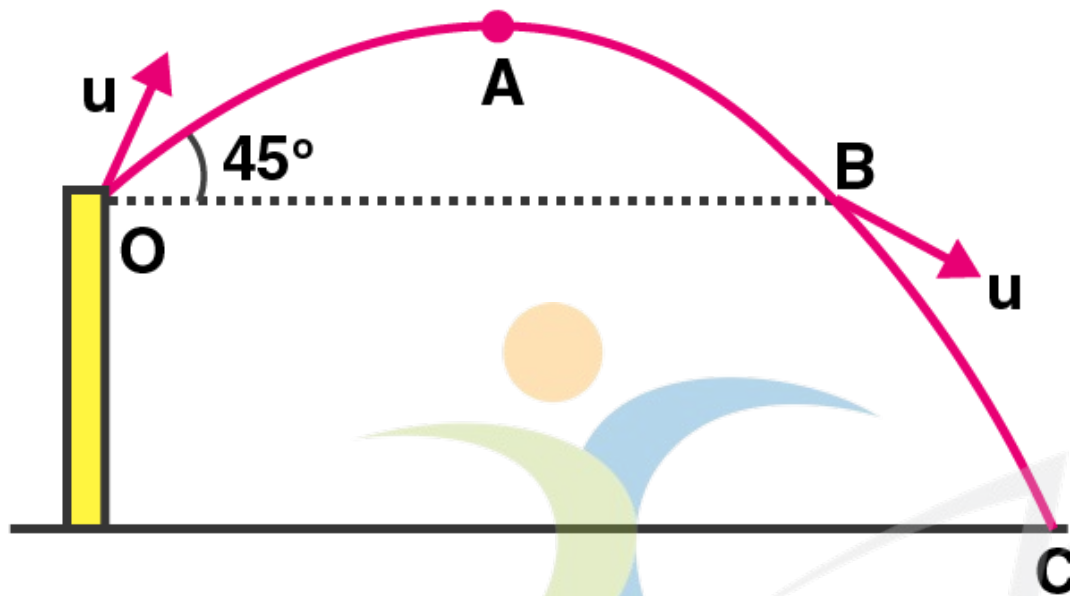
- a) greatest speed**
- b) smallest speed**
- c) greatest acceleration?**

**Explain**

**Answer:**

a) Let us assume that the ball is projected from the point O at an angle  $45^\circ$ . From O to A there is an increase in the height of the ball such that the KE of the ball decreases. The height from point A to B decreases making the speed increase and now it is equal to the initial speed when the ball was at point O. This is because O and B are in the same horizontal line. From point B to C, again the speed increases as the height has reduced. Therefore, the greatest speed is at C as  $v_y$  maximum and  $v_x = u/\sqrt{2}$ .

tamso ma jyotirgamaya



b) The smallest speed will be at point A as the height at this point is the highest and  $v_y = 0$  as the horizontal speed is the only constant value ie;  $u/\sqrt{2}$

c) The greatest acceleration is acceleration due to gravity as only gravitational force is acting on the ball and in downward direction.

**4.19. A football is kicked into the air vertically upwards. What is its**

**a) acceleration**

**b) velocity at the highest point**

**Answer:**

a) The acceleration of the football will be downward when it is kicked upwards as only gravitational force is acting on it.

b) The football will have its highest velocity when  $v_y = 0$ .

**4.20. A, B, and C are three non-collinear, non co-planar vectors. What can you say about direction of  $A(B \times C)$ ?**

**Answer:**

The direction of product of vectors B and C is perpendicular to the plane that contains vector B and C which is based on the Right hand grip rule.

The direction of vector  $A(B \times C)$  is perpendicular to vector A and is in the plane which contains vectors B and C and is again based on the Right hand grip rule.

**Short Answers**

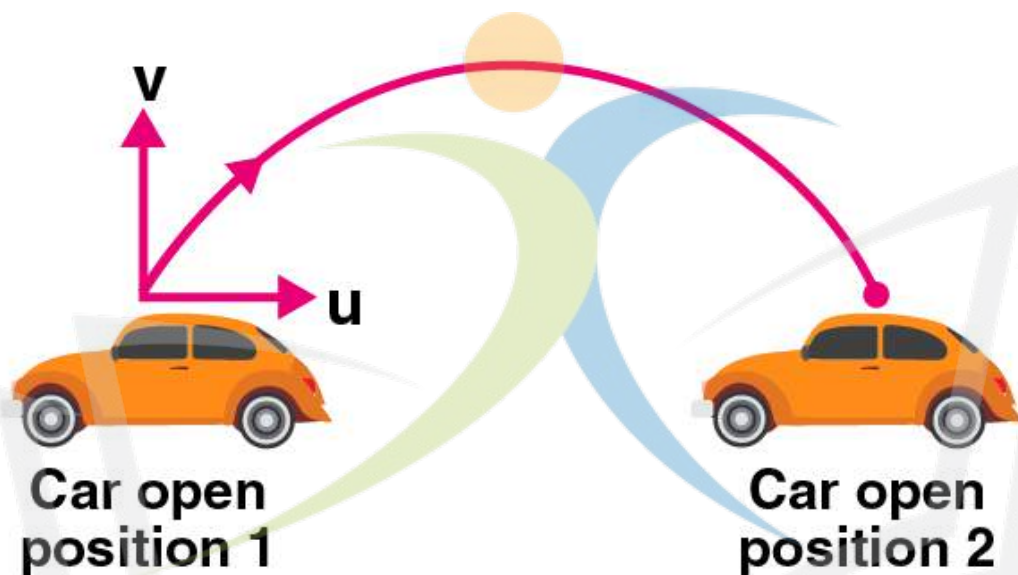
**4.21. A boy travelling in an open car moving on a labelled road with constant speed tosses a ball vertically up in the air and catches it back. Sketch the motion of the ball as observed by a boy standing on the footpath. Give explanation to support your diagram.**

**Answer:**

Given,

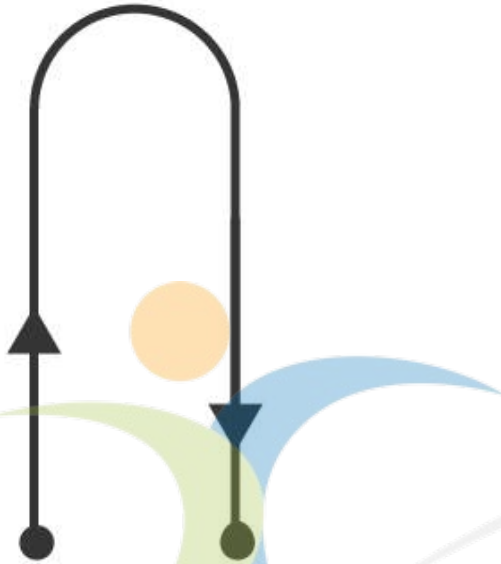
$v$  = vertical velocity of the ball that the boy has

$u$  = velocity of the car which is equal to the horizontal velocity of the ball



Above is the diagram which is viewed by the observer on the footpath. The diagram is parabolic as the vertical and horizontal components of the velocities are viewed by the observer.

**NAGEEN GROUP**  
tamso ma jyotirgamaya



Above is the diagram which is viewed by the boy sitting in the same car which is moving vertically up-down and is under the action of gravity. For car and boy to catch up, the car should move with constant velocity.

**4.22. A boy throws a ball in air at  $60^\circ$  to the horizontal along a road with a speed of 10 m/s. Another boy sitting in a passing by car observes the ball. Sketch the motion of the ball as observed by the boy in the car, if car has a speed of 18 km/h. Give explanation to support your diagram.**

**Answer:**

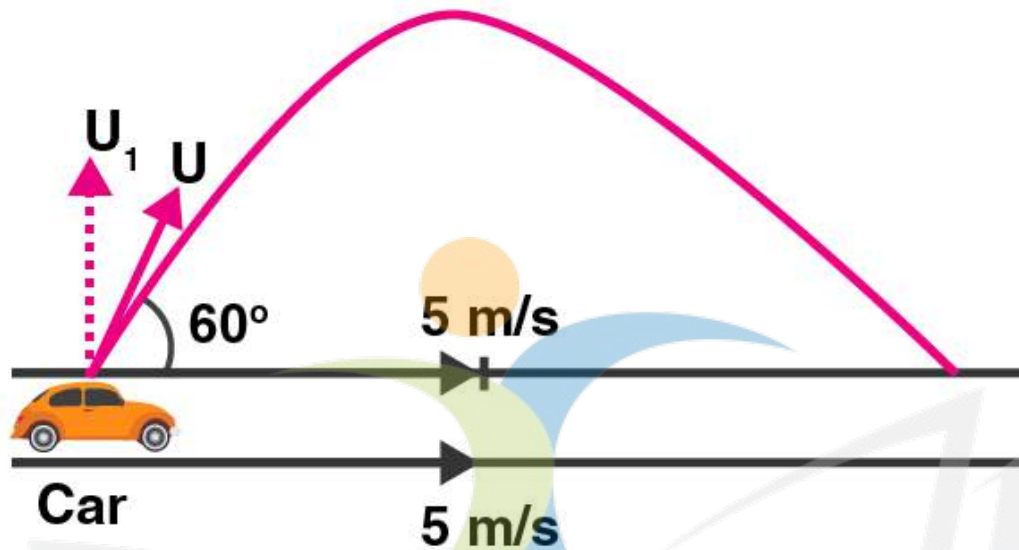
Given,

$$u = 36 \text{ km/h} = 10 \text{ m/s}$$

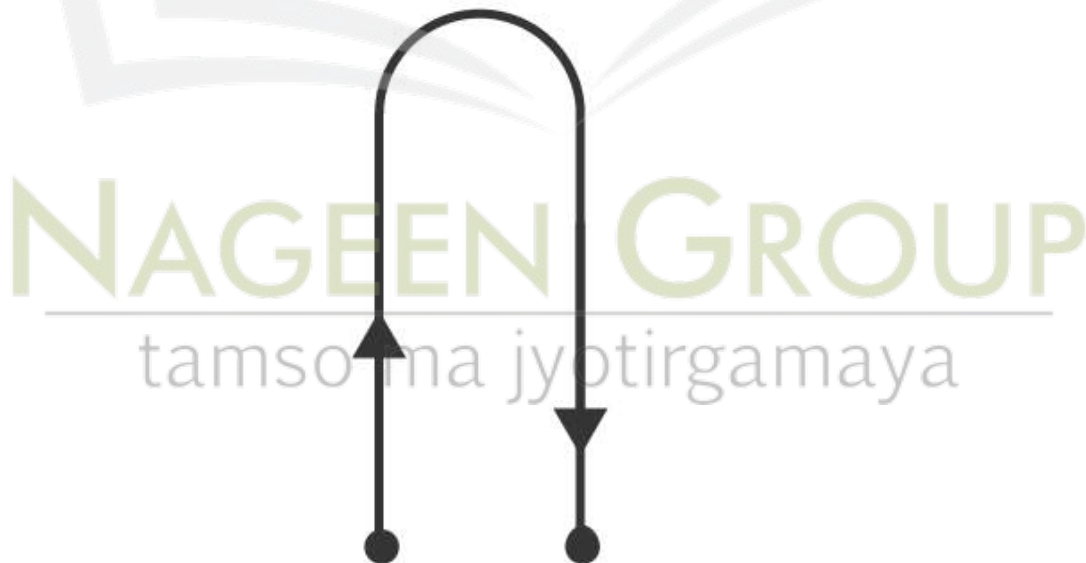
$$u_x = u \cos 60^\circ = 5 \text{ m/s}$$

$$\text{Speed of the car in the direction of motion of ball} = (18)(5/18) = 5 \text{ m/s}$$

**NAGEEN GROUP**  
tamso ma jyotirgamaya



Following is the diagram of the ball thrown by the boy when the car passes him. Both, car as well as ball are in the horizontal distances and speeds that are equal to each other. But the vertical component of velocity is  $u_y = u \cos 30^\circ = 5\sqrt{3} \text{ m/s}$ . The motion of the ball according to the boy sitting in the car is in vertically up-down motion.



**4.23. In dealing with motion of projectile in air, we ignore effect of air resistance on motion. This gives**



**trajectory as a parabola as you have studied. What would the trajectory look like if air resistance is included? Sketch such a trajectory and explain why you have drawn it that way.**

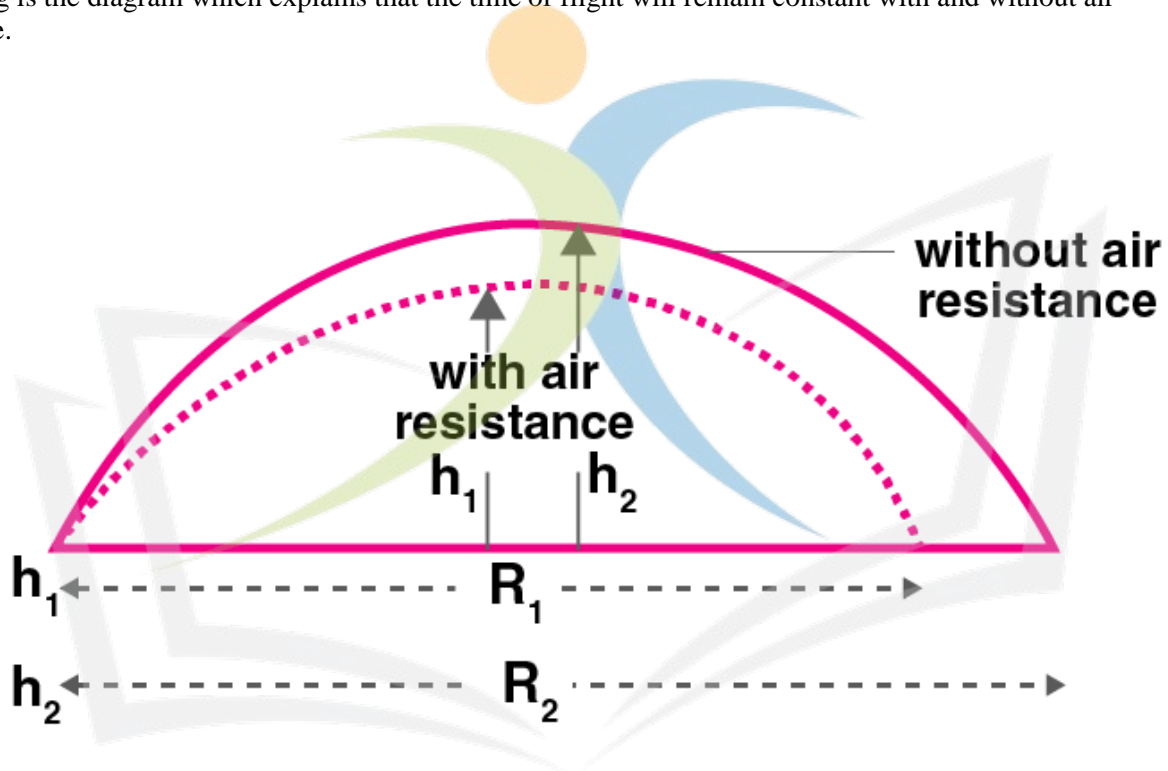
**Answer:**

When the air resistance acting on the projectile motion is considered, the vertical and horizontal velocity decreases due to air resistance. Following is the formula which is responsible for reducing the height of the motion and this is smaller than the height which exists when there is no force of friction:

$$R = (u^2/g) \sin 2\theta$$

$$H_{\max} = u^2 \sin^2 \theta / 2g$$

Following is the diagram which explains that the time of flight will remain constant with and without air resistance.



Therefore,  $h_1 < h_2$  and  $R_1 < R_2$ .

**4.24. A fighter plane is flying horizontally at an altitude of 1.5 km with speed 720 km/h. At what angle of sight when the target is seen, should the pilot drop the bomb in order to attack the target? —**

**Answer:**

Given,

$$u = 720 \text{ km/h} = 200 \text{ m/s}$$

Let  $t$  be the time at which pilot drops the bomb, then  $Q$  will be the point vertically above the target  $T$ .

We also know that the horizontal velocity of the bomb is equal to the velocity of the fighter plane. But the vertical component is zero. When the bomb reaches  $TQ$ , it is a free falling object with initial velocity equal to zero.

$$u = 0$$

$$H = 1.5 \text{ km} = 1500 \text{ m}$$

$$H = ut + \frac{1}{2}gt^2$$

Substituting the values, we get

$$t = 10\sqrt{3} \text{ second.}$$

Let the distance between  $PQ$  be  $ut$ .

Therefore,  $PQ = 2000\sqrt{3} \text{ m}$

$$\tan \theta = \sqrt{3}/4$$

$$\tan \theta = \tan^{-1} 23^\circ 42'$$

$$\theta = 23^\circ 42'$$

**4.25. a) Earth can be thought of as a sphere of radius 6400 km. Any object is performing circular motion around the axis of earth due to earth's rotation. What is acceleration of object on the surface of the earth towards its centre? What is it at latitude  $\theta$ ? How does these accelerations compare with  $g = 9.8 \text{ m/s}^2$ ?**

**b) Earth also moves in circular orbit around sun once every year with an orbital radius of  $1.5 \times 10^{11} \text{ m}$ . What is the acceleration of earth towards the centre of the sun? How does this acceleration compare with  $g = 9.8 \text{ m/s}^2$ ?**

**Answer:**

a) From the problem,

$$\text{Radius of the earth, } R = 6400 \text{ km} = 6.4 \times 10^6 \text{ m}$$

$$\text{Time period, } T = 1 \text{ day} = 24 \times 60 \times 60 = 86400 \text{ s}$$

$$\text{Centripetal acceleration, } a_c = \omega^2 R = (4\pi^2 R)/T^2$$

Substituting the values, we get

$$a_c = 0.034 \text{ m/s}^2$$

At equator, latitude  $\theta = 0^\circ$

We know that,

$$a_c/g = 0.034/9.8 = 1/288$$

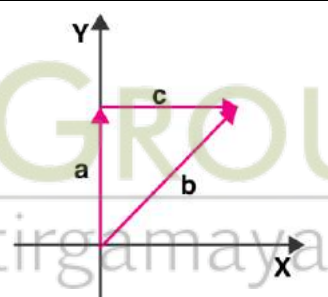
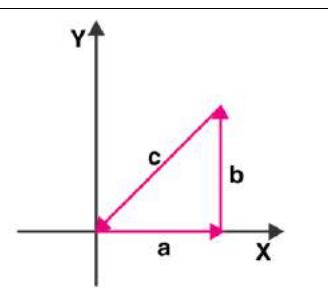
b) Orbital radius of the earth around the sun,  $R = 1.5 \times 10^{11} \text{ m}$

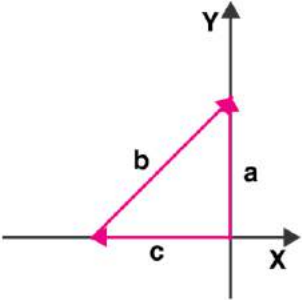
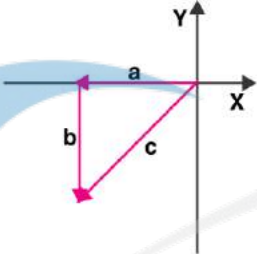
$$\text{Time period} = 1 \text{ year} = 365 \text{ days} = 3.15 \times 10^7 \text{ s}$$

$$\text{Centripetal acceleration, } a_c = \omega^2 R = (4\pi^2 R)/T^2 = 5.97 \times 10^{-3} \text{ m/s}^2$$

$$a_c/g = 5.97 \times 10^{-3}/9.8 = 1/1642$$

**4.26 Given below in column I are the relations between vectors a, b, and c and in column II are the orientations of a, b, and c in the XY plane. Match the relation in column I to correct orientations in column II.**

Column I	Column II
a) $a + b = c$	 <p>i)</p>
b) $a - c = b$	 <p>ii)</p>

c) $b - a = c$	 iii)
d) $a + b + c = 0$	 iv)

**Answer:**

- a) matches with iv)
- b) matches with iii)
- c) matches with i)
- d) matches with ii)

4.27. If  $|A| = 2$  and  $|B| = 4$ , then match the relations in column I with the angle between  $\theta$  between A and B in column II.

Column I	Column II
a) $A \cdot B = 0$	i) $\theta = 0^\circ$
b) $A \cdot B = +8$	ii) $\theta = 90^\circ$
c) $A \cdot B = 4$	iii) $\theta = 180^\circ$
d) $A \cdot B = -8$	iv) $\theta = 0^\circ$

**Answer:**

- a) matches with ii)
- b) matches with i)
- c) matches with iv)
- d) matches with iii)

4.28. If  $|A| = 2$  and  $|B| = 4$ , then match the relations in column I with the angle  $\theta$  between A and B in column II.

Column I	Column II
a) $ A \times B  = 0$	i) $\theta = 30^\circ$
b) $ A \times B  = 8$	ii) $\theta = 45^\circ$
c) $ A \times B  = 4$	iii) $\theta = 90^\circ$
d) $ A \times B  = 4\sqrt{2}$	iv) $\theta = 0^\circ$

**Answer:**

- a) matches with iv)
- b) matches with iii)
- c) matches with i)
- d) matches with ii)

## Long Answers

**4.29.** A hill is 500 m high. Supplies are to be sent across the hill using a canon that can hurl packets at a speed of 125 m/s over the hill. The canon is located at a distance of 800 m from the foot of hill and can be moved on the ground at a speed of 2 m/s so that its distance from the hill can be adjusted. What is the shortest time in which a packet can reach on the ground across the hill? Take  $g = 10 \text{ m/s}^2$ .

**Answer:**

Given,

Speed of packets = 125 m/s

Height of the hill = 500 m

Distance between the canon and the foot of the hill,  $d = 800 \text{ m}$

The vertical component of the velocity should be minimum so that the time taken to cross the hill will be the shortest.

$$u_y = \sqrt{2gh} \geq \sqrt{(2)(10)(500)} \geq 100 \text{ m/s}$$

But,

$$u^2 = u_x^2 + u_y^2$$

Therefore, horizontal component of the initial velocity,

$$u_x = \sqrt{u^2 - u_y^2}$$

$$u_x = 75 \text{ m/s}$$

Time taken by the packet to reach the top of the hill,

$$t = \sqrt{\frac{2h}{g}}$$

$$t = 10 \text{ s}$$

Time taken to reach the ground from the top of the hill =  $t' = t = 10 \text{ s}$

Horizontal distance covered in 10s =  $(75)(10) = 750 \text{ m}$

Therefore, time taken by canon =  $50/2 = 25 \text{ s}$

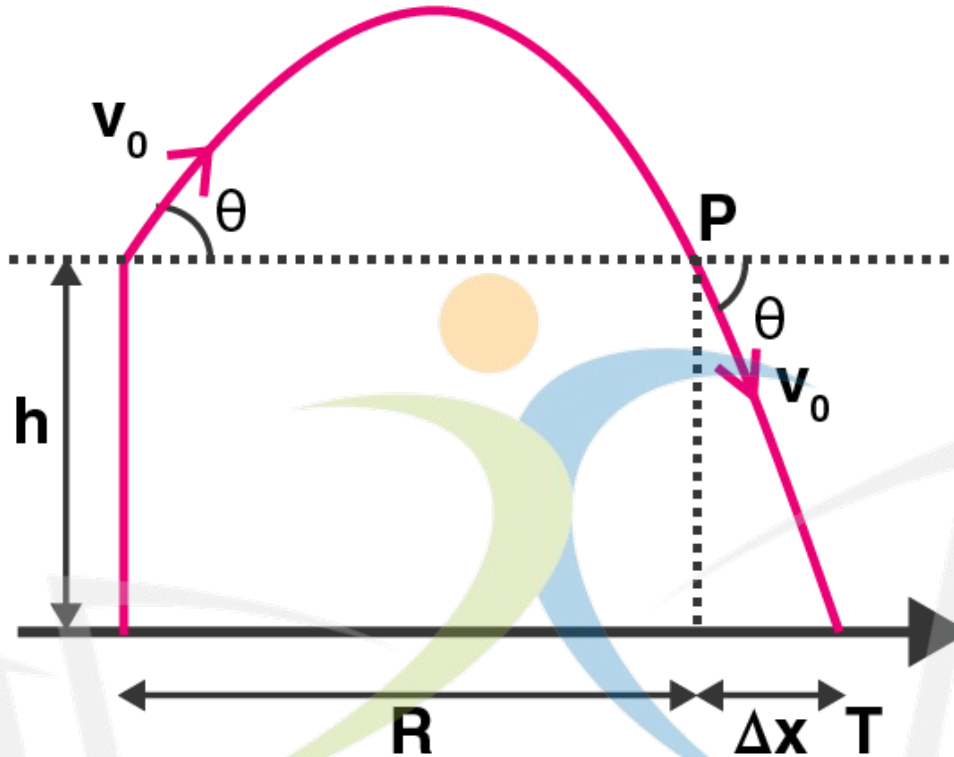
Therefore, total time taken by a packet to reach the ground =  $25 + 10 + 10 = 45 \text{ s}$ .

**4.30.** A gun can fire shells with maximum speed  $v_0$  and the maximum horizontal range that can be

$$R = \frac{v_0^2}{g}$$

achieved is

. If a target farther away by distance  $\Delta x$  has to be hit with the same gun, show that it could be achieved by raising the gun to a height at least  $h = \Delta x[1 + \Delta x/R]$



Answer:

$$R = \frac{v_0^2}{g}$$

Which is the maximum range of projectile

Therefore, the angle of projection,  $\theta = 45^\circ$

The gun is placed at a height  $h$  so that it can hit the target

The vertical downward direction is taken as negative

Horizontal component of initial velocity =  $v_0 \cos \theta$

Vertical component of initial velocity =  $v_0 \sin \theta$

Displacement along y-axis,  $-h = (v_0 \sin \theta)t + \frac{1}{2}(-g)t^2$

Displacement along x-axis,  $t = (R + \Delta x)/v_0 \cos \theta$

Substituting all the equations, we get

$$h = \Delta x (1 + \Delta x/R)$$

**4.31. A particle is projected in air at an angle  $\beta$  to a surface which itself is inclined at an angle  $\alpha$  to the horizontal.**

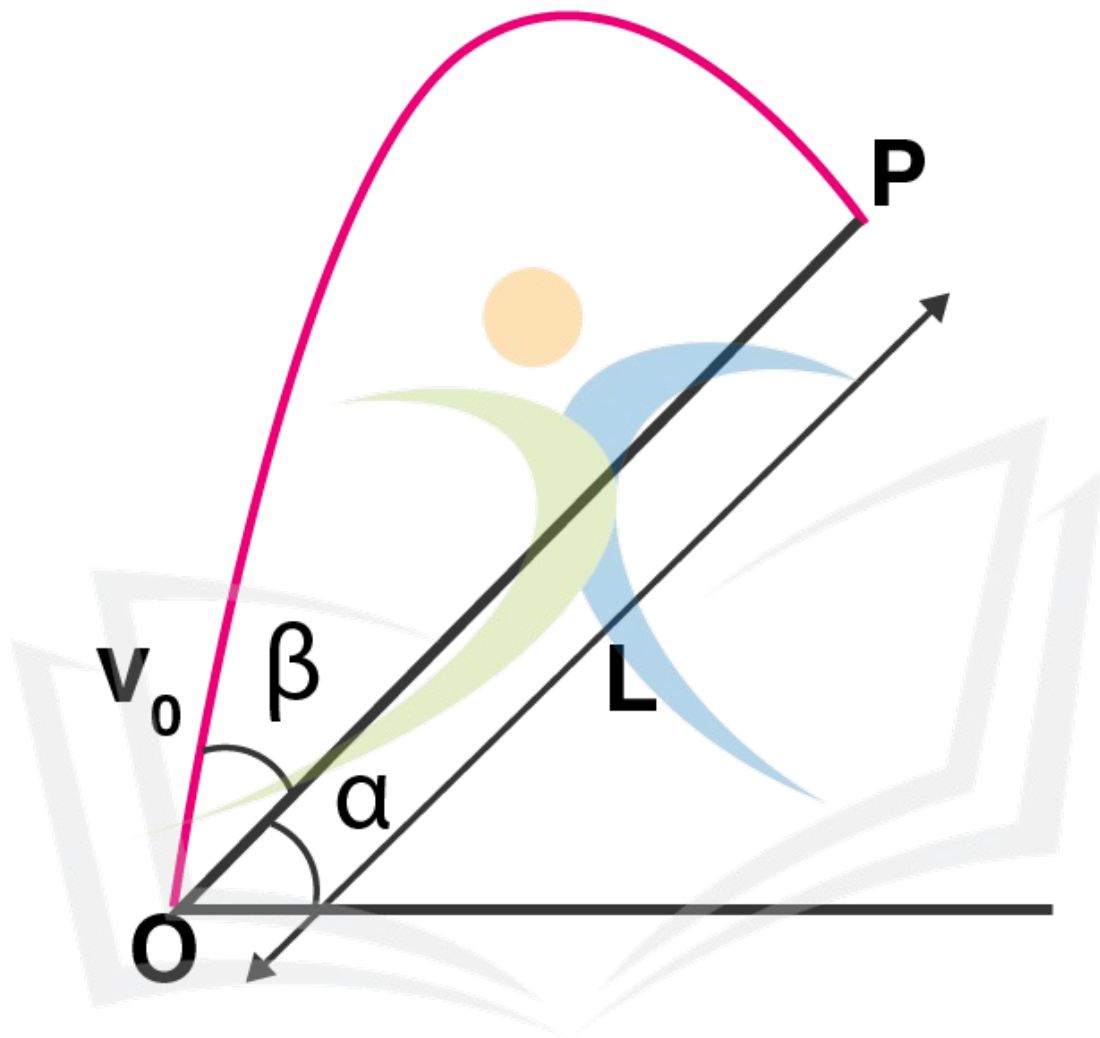
**a) find an expression of range on the plane surface**

**b) time of flight**

**c)  $\beta$  at which range will be maximum**

**Answer:**





a) Time of flight,  $T =$

$$\frac{2u \sin(\alpha + \beta)}{g \cos \beta}$$

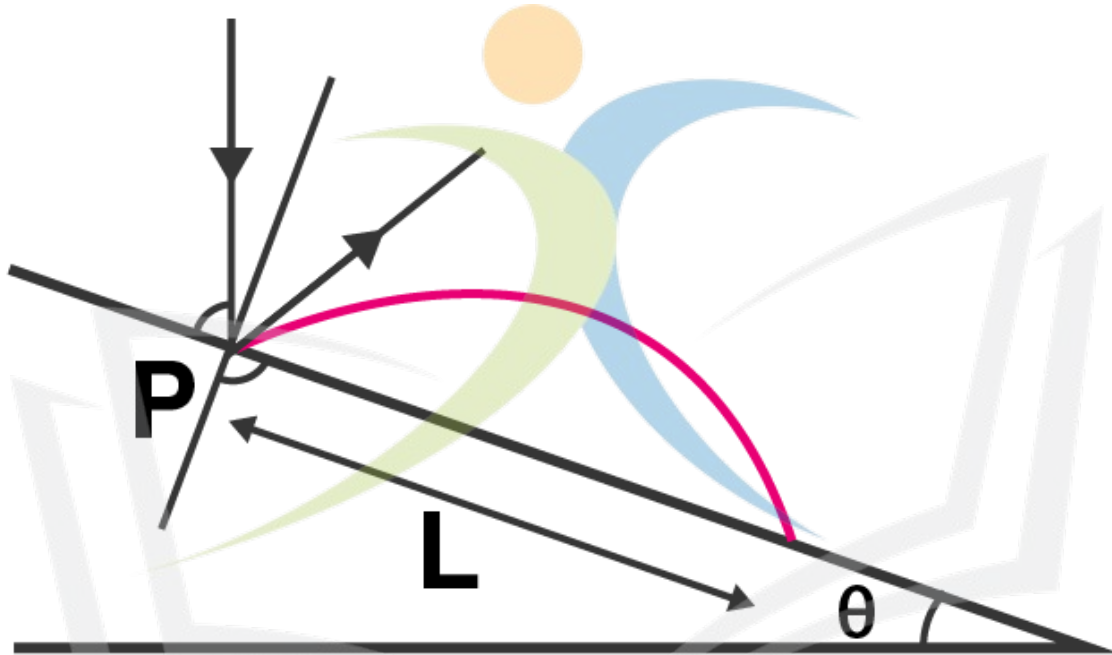
b) Range down an inclined plane,  $R =$

$$\frac{2u^2 \sin(\alpha + \beta) \cos \alpha}{g \cos^2 \beta}$$

c) Maximum range down an inclined plane,  $R_{\max} =$

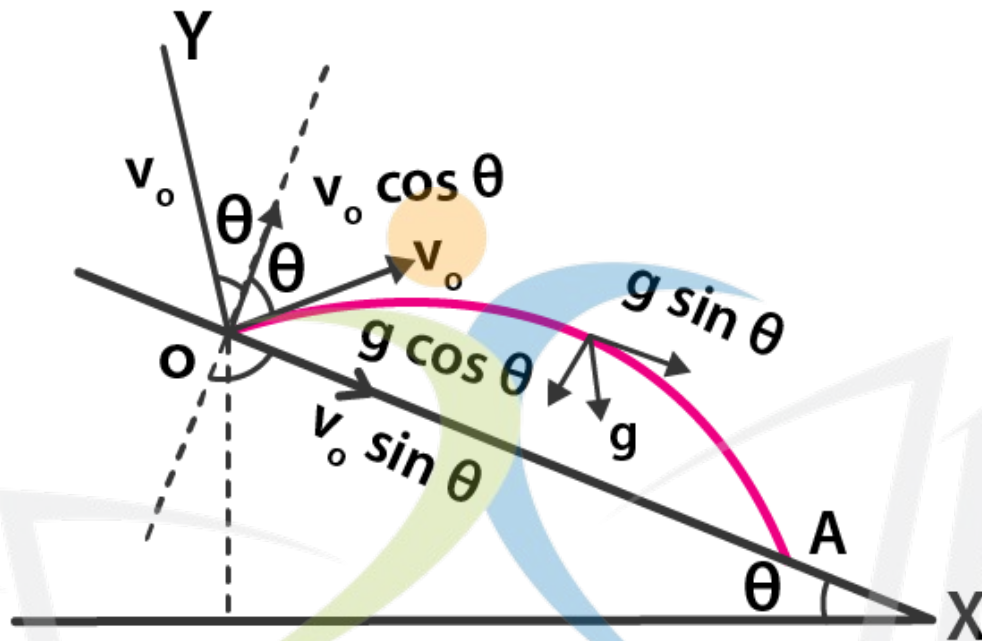
$$\frac{u^2}{g(1 - \sin \beta)}$$

4.32. A particle falling vertically from a height hits a plane surface inclined to horizontal at an angle  $\theta$  with speed  $v_0$  and rebounds elastically. Find the distance along the plane where it will hit second time.



Answer:

**NAGEEN GROUP**  
tamso ma jyotirgamaya



When x and y axes are selected as shown in the diagram, the motion of projectile from O to A is

$$y = 0$$

$$u_y = v_o \cos \theta$$

$$a_y = -g \cos \theta$$

$$t = T$$

With the help of kinematics for y-axis

$$y = u_y t + \frac{1}{2} a_y t^2$$

$$T = \frac{2v_o \cos \theta}{g \cos \theta}$$

With the help of kinematics for x-axis

$$x = u_x t + \frac{1}{2} a_x t^2$$

$$L = \frac{4v_o^2}{g} \sin \theta$$

**4.33. A girl riding a bicycle with a speed of 5 m/s towards north direction, observes rain falling vertically down. If she increases her speed to 10 m/s, rain appears to meet her at  $45^\circ$  to the vertical. What is the speed of the rain? In what direction does rain fall as observed by a ground based observer?**

**Answer:**

Let  $V_{rg}$  be the velocity of the rain drop that appears to the girl.

All the vectors are drawn in reference to the frame from the ground.

Let the velocity of rain be:

$$v_r = a\hat{i} + b\hat{j}$$

### Case I

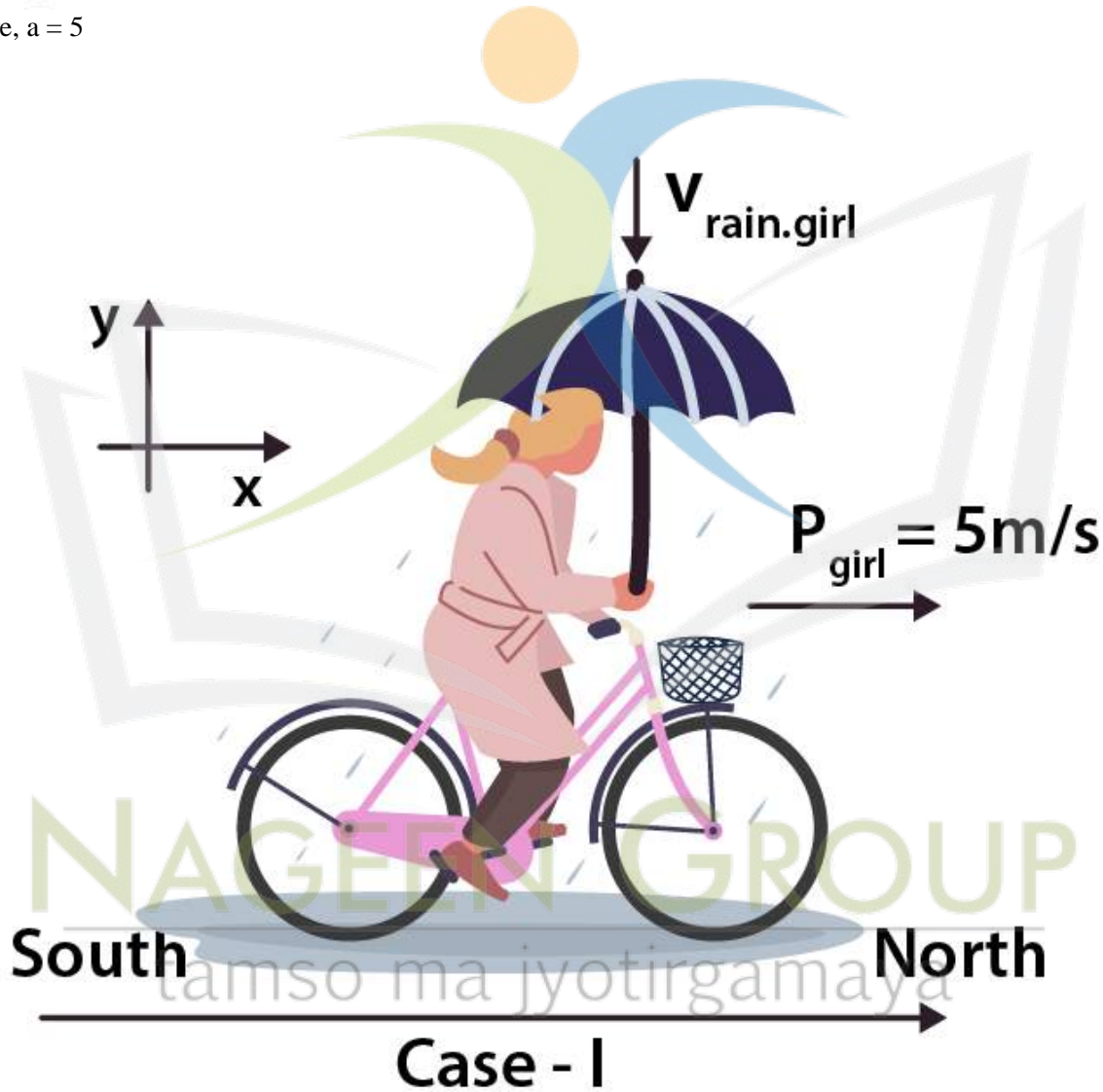
According to the problem, the velocity of girl =  $v_g$

Let  $v_{rg}$  be the velocity of rain with respect to the girl

The equation which is used for determining a is:

$$v_r - v_g = (a\hat{i} + b\hat{j}) - 5\hat{i} = (a - 5)\hat{i} + b\hat{j}$$

Therefore,  $a = 5$



### Case II

Now the velocity of the girl has increased =  $v_g$

Following is the equation that is used for determining the value of b at  $\tan 45^\circ$ .

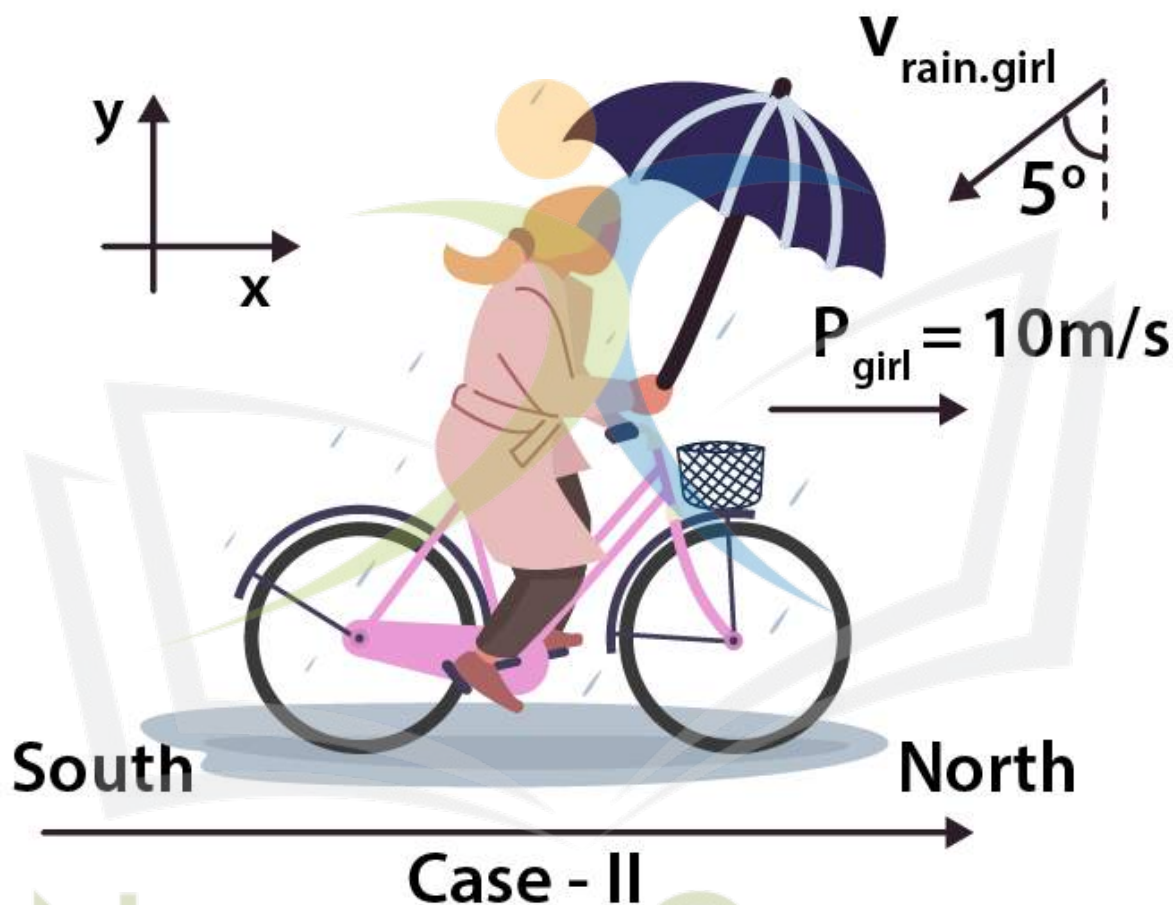
$$v_r - v_g = (a\hat{i} + b\hat{j}) - 10\hat{i} = (a - 10)\hat{i} + b\hat{j}$$

Therefore, the velocity of rain is:

$$v_r = 5\hat{i} - 5\hat{j}$$

Speed of rain is:

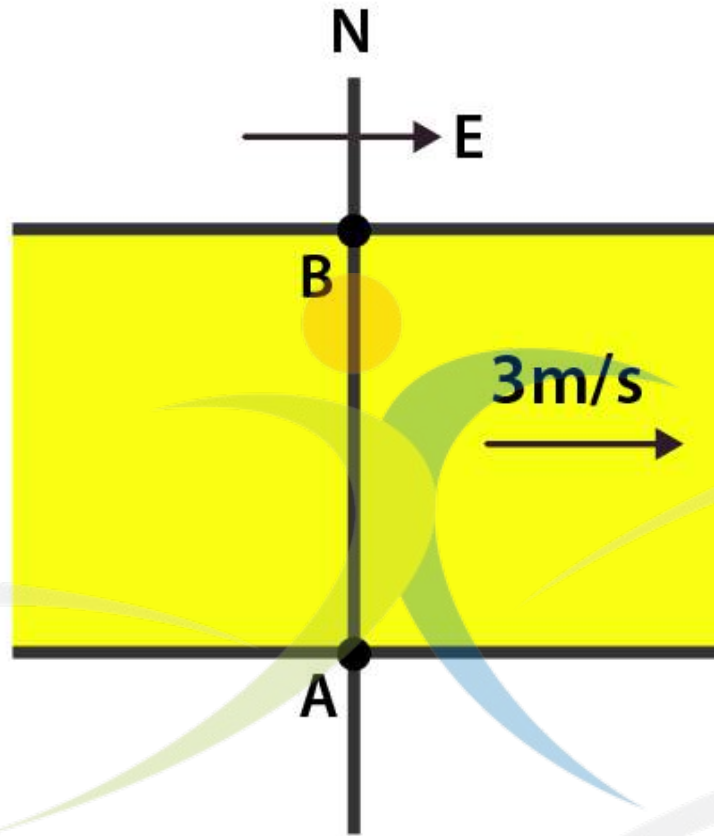
$$|v_r| = \sqrt{5^2 + (-5)^2} = \sqrt{50} = 5\sqrt{2} \text{ m/s}$$



4.34. A river is flowing due east with a speed 3 m/s. A swimmer can swim in still water at a speed of 4 m/s.

- if swimmer starts swimming due north, what will be his resultant velocity?
- if he wants to start from point A on south bank and reach opposite point B on north bank,
  - which direction should he swim?
  - what will be his resultant speed?
- from two different cases as mentioned in a) and b) above, in which case will he reach opposite bank in shorter time?





**Answer:**

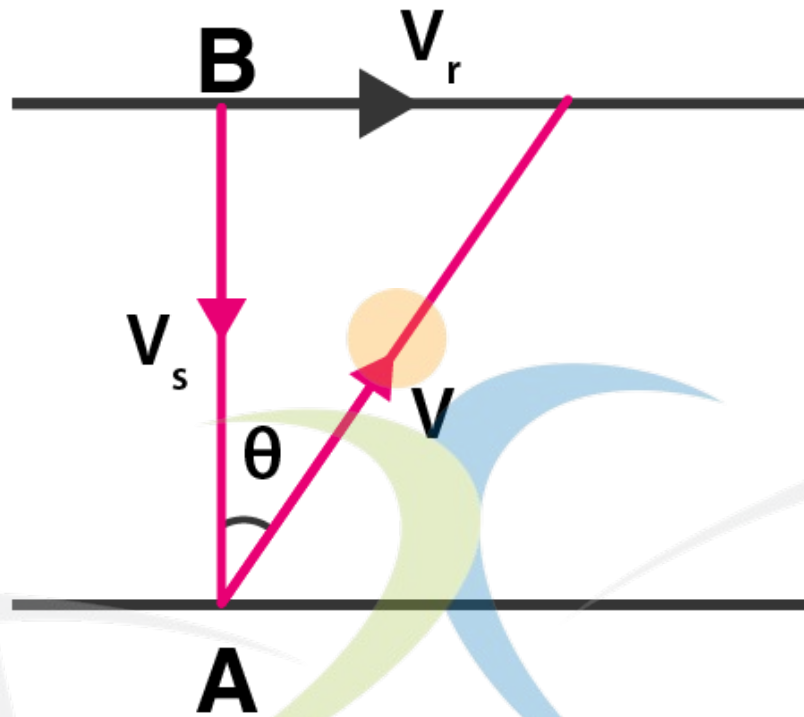
Given,

Speed of the river,  $v_r = 3 \text{ m/s}$

Velocity of swimmer,  $v_s = 4 \text{ m/s}$

a) When the swimmer swims due north, the y-component has the velocity 4 m/s and x-component will have 3 m/s. following is the resultant velocity with respect to  $\tan \theta$

**NAGEEN GROUP**  
tamso ma jyotirgamaya

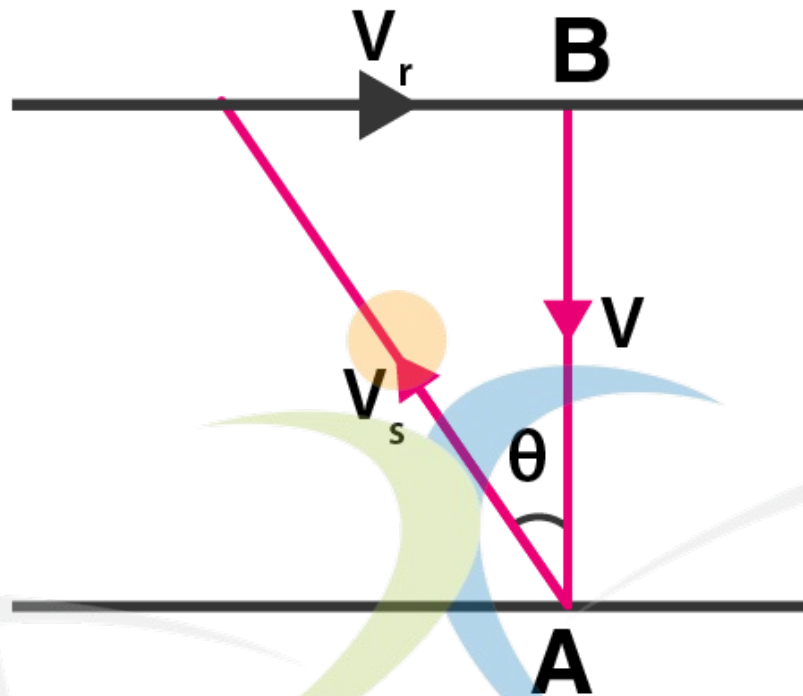


$$v = \sqrt{v_r^2 + v_s^2} = \sqrt{(3)^2 + (4)^2} = 5 \text{ m/s}$$

$$\theta = 37^\circ \text{N}$$

b) Following is the resultant speed of the swimmer when he wants to reach the point which is directly opposite to him and which is with respect to  $\tan \theta$

**NAGEEN GROUP**  
tamso ma jyotirgamaya



$$v = \sqrt{v_s^2 - v_r^2} = \sqrt{(4)^2 - (3)^2} = \sqrt{7} \text{ m/s}$$

$\theta = \tan^{-1}(3/\sqrt{7})$  of north

c) Time taken in case a) is  $d/4$  sec

Time taken in case b) is  $d/\sqrt{7}$

As  $d/4 < d/\sqrt{7}$ , time taken in case a) is shorter than case b).

**4.35.** A cricketer can throw the cricket ball with a speed  $v_0$ . If he throws the ball while running with speed  $u$  at an angle  $\theta$  to the horizontal, find

a) the effective angle to the horizontal at which the ball is projected in air as seen by a spectator

b) what will be time of flight?

c) what is the distance from the point of projection at which the ball will land?

d) find  $\theta$  at which he should throw the ball that would maximise the horizontal range as found c)

e) how does  $\theta$  for maximum range change if  $u > v_0$ ,  $u = v_0$  and  $u < v_0$

f) how does  $\theta$  in e) compare with that for  $u = 0$ ?

**Answer:**

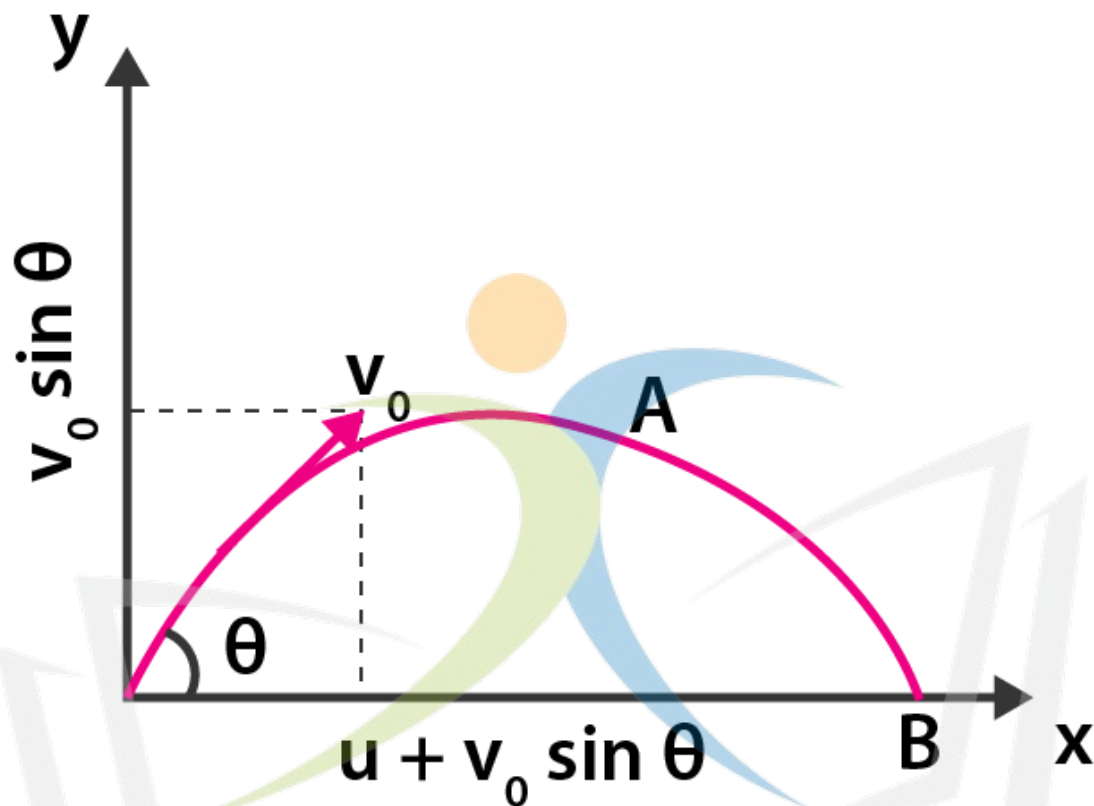
Initial velocity in x-direction,

$$u_x = u + v_0 \cos \theta$$

Initial velocity in y-direction,

$$u_y = v_0 \sin \theta$$

where  $\theta$  is the angle of projection



a) The angle of projection with the horizontal with respect to spectator is:

$$\tan \theta = u_y / u_x$$

$$\theta = \tan^{-1} \left( \frac{v_0 \sin \theta}{u + v_0 \cos \theta} \right)$$

b) When the displacement along the y-axis is zero over the time period T

$$y = 0$$

$$u_y = v_0 \sin \theta$$

$$a_y = -g$$

$$t = T$$

We know that,

$$y = u_y T + \frac{1}{2} a_y t^2$$

Solving for T, we get

$$T = 2 u_0 \sin \theta / g$$

c) Horizontal range is

$$R = \frac{v_0}{g} [2u \sin\theta + v_0 \sin 2\theta]$$

d) For horizontal range,  $dR/d\theta = 0$

Then  $\theta_{\max}$  is:

$$\theta_{\max} = \cos^{-1}\left(\frac{-u + \sqrt{u^2 + 8v_0^2}}{4v_0}\right)$$

e) If  $u = v_0$ ,

$\theta_{\max} = \pi/2$

f) If  $u = 0$ ,  $\theta_{\max} = 45^\circ$

Then,  $u = 0$  and  $\theta \geq 45^\circ$

**4.36. Motion in two dimensions, in a plane can be studied by expressing position, velocity, and acceleration**

as vector in Cartesian coordinates  $A = A_x \hat{i} + A_y \hat{j}$  where  $\hat{i}$  and  $\hat{j}$  are unit vectors along x and y directions, respectively and  $A_x$  and  $A_y$  are corresponding components of A. Motion can also be studied by

expressing vectors in circular polar coordinates as  $A = A_r \hat{r} + A_\theta \hat{\theta}$  where

$\hat{r} = \frac{\mathbf{r}}{r} = \cos\theta \hat{i} + \sin\theta \hat{j}$  and  $\hat{\theta} = -\sin\theta \hat{i} + \cos\theta \hat{j}$  are unit vectors along direction in which r and  $\theta$  are increasing.

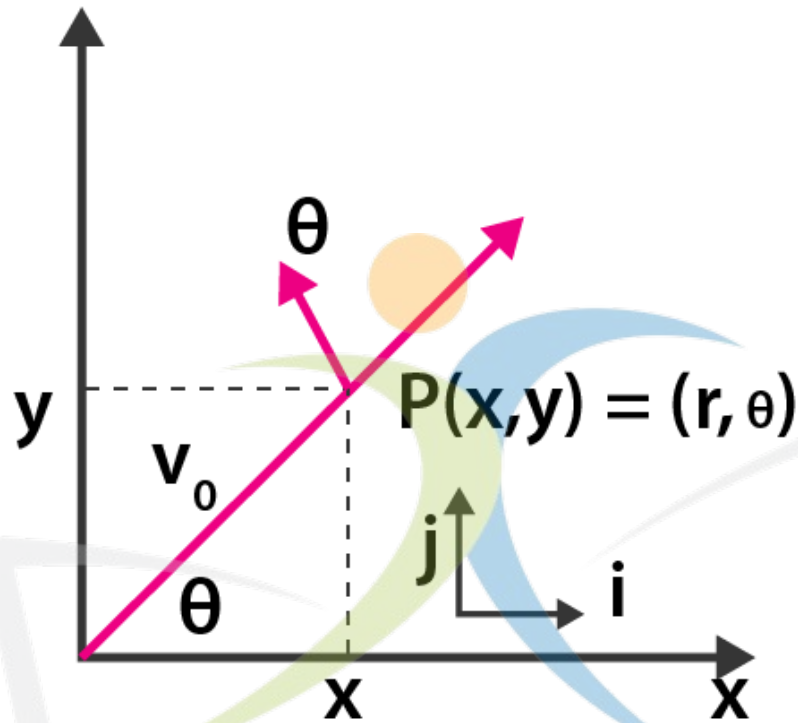
a) express  $\hat{i}$  and  $\hat{j}$  in terms of  $\hat{r}$  and  $\hat{\theta}$

b) show that both  $\hat{r}$  and  $\hat{\theta}$  are unit vectors and are perpendicular to each other

c) show that  $\frac{d}{dt}(\hat{r}) = \omega \hat{\theta}$  where  $\omega = \frac{d\theta}{dt}$  and  $\frac{d}{dt}(\hat{\theta}) = -\omega \hat{r}$

d) for a particle moving along a spiral given by  $r = a\theta$  where  $a = 1$  find dimensions of 'a'

e) find velocity and acceleration in polar vector representation for particle moving along spiral described in d) above



**Answer:**

a) The unit vector is given as:

$$\hat{r} = \cos\theta\hat{i} + \sin\theta\hat{j} \text{ and } \hat{\theta} = -\sin\theta\hat{i} + \cos\theta\hat{j}$$

Solving the above equations we get unit vector as:

$$\hat{i} = n(\hat{r}\cos\theta - \hat{\theta}\sin\theta)$$

b)

$$\hat{r} \cdot \hat{i} = (\cos\theta\hat{i} + \sin\theta\hat{j}) \cdot (-\sin\theta\hat{i} + \cos\theta\hat{j})$$

$\theta = 90^\circ$ , angle between  $\hat{r}$  and  $\hat{\theta}$

c) Given,

$$\hat{r} = \cos\theta\hat{i} + \sin\theta\hat{j}$$

Solving the above gives:



$$\hat{r} = \omega[-\sin\theta\hat{i} + \cos\theta\hat{j}]$$

d) Given,

$$r = a\theta\hat{r}$$

$$[a] = L = [M^0L^1T^0]$$

e) Given,

$$a = 1 \text{ unit}$$

$$r = \theta\hat{r} = \theta[\cos\theta\hat{i} + \sin\theta\hat{j}]$$

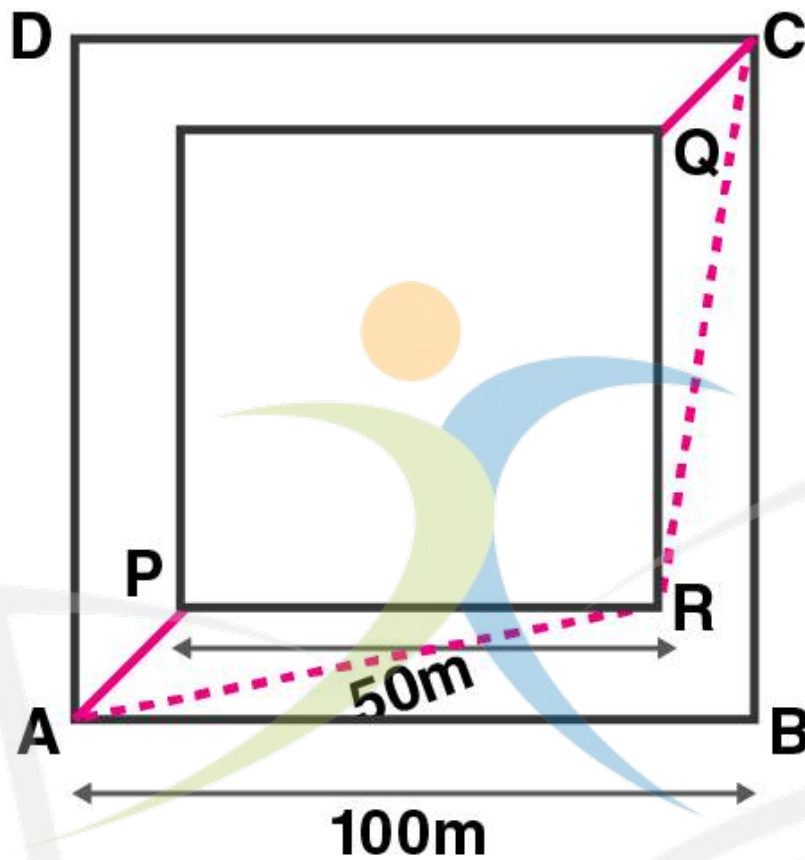
Differentiating the above equation, we get velocity as:

$$v = \frac{d\theta}{dt}\hat{r} + \theta\hat{\theta} = \omega\hat{r} + \omega\theta\hat{\theta}$$

By differentiating the above equation we can find acceleration as:

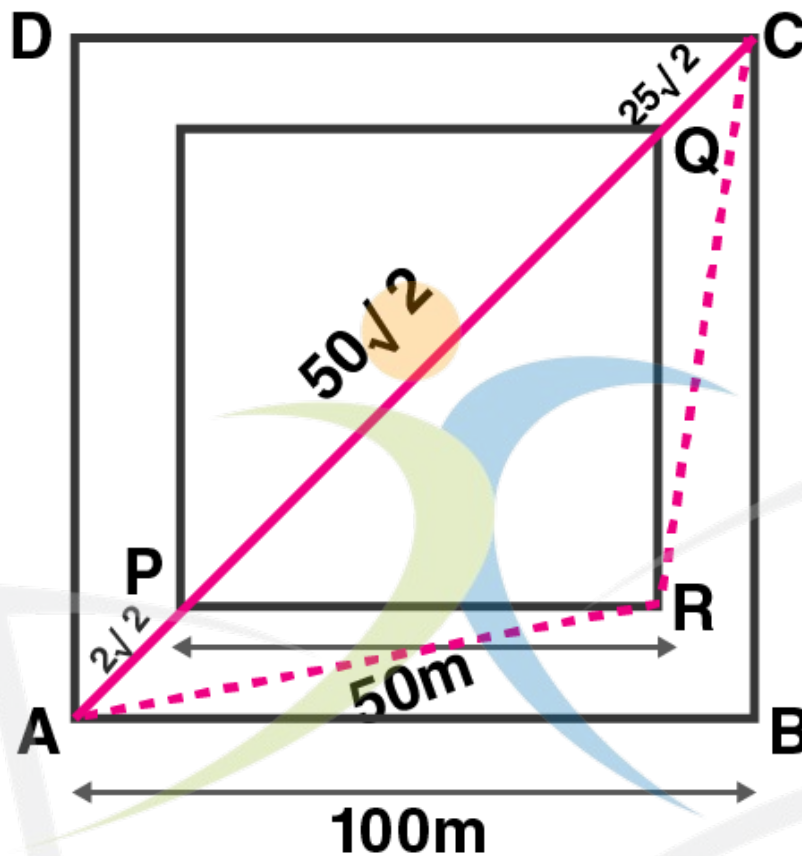
$$a = \left(\frac{d^2\theta}{dt^2} - \omega^2\right)\hat{r} + \left(2\omega^2 + \frac{d^2\theta}{dt^2}\right)\theta\hat{\theta}$$

**4.37. A man wants to reach from A to the opposite corner of the square C. The sides of the square are 100 m. A central square of 50 m × 50 m is filled with sand. Outside this square, he can walk at a speed 1 m/s. In the central square, he walk only at a speed of v m/s. What is smallest value of v for which he can reach faster via a straight path through the sand than any path in the square outside the sand?**



Answer:

**NAGEEN GROUP**  
tamso ma jyotirgamaya



As shown in the diagram, APQC is the path taken by the man through the sand, time taken by him to go from A to C,

$$T_{sand} = \frac{AP + QC}{1} + \frac{PQ}{v}$$

$$= 50\sqrt{2}(1/v + 1)$$

The shortest path will be ARC from the diagram.

$$T_{outside} = AR + RC / 1 \text{ s}$$

$$AR = \sqrt{75^2 + 25^2}$$

$$RC = AR = 25\sqrt{10} \text{ s}$$

$$T_{sand} < T_{outside}$$

$$V > 0.81 \text{ m/s}$$

# CLICK TO DOWNLOAD NCERT EXEMPLAR SOLUTIONS

**CLASS 11: PHYSICS (ALL CHAPTERS)**





# JOIN OUR WHATSAPP GROUPS

FOR FREE EDUCATIONAL  
RESOURCES

---





## JOIN SCHOOL OF EDUCATORS WHATSAPP GROUPS FOR FREE EDUCATIONAL RESOURCES

We are thrilled to introduce the School of Educators WhatsApp Group, a platform designed exclusively for educators to enhance your teaching & Learning experience and learning outcomes. Here are some of the key benefits you can expect from joining our group:

### BENEFITS OF SOE WHATSAPP GROUPS

---

- **Abundance of Content:** Members gain access to an extensive repository of educational materials tailored to their class level. This includes various formats such as PDFs, Word files, PowerPoint presentations, lesson plans, worksheets, practical tips, viva questions, reference books, smart content, curriculum details, syllabus, marking schemes, exam patterns, and blueprints. This rich assortment of resources enhances teaching and learning experiences.
- **Immediate Doubt Resolution:** The group facilitates quick clarification of doubts. Members can seek assistance by sending messages, and experts promptly respond to queries. This real-time interaction fosters a supportive learning environment where educators and students can exchange knowledge and address concerns effectively.
- **Access to Previous Years' Question Papers and Topper Answers:** The group provides access to previous years' question papers (PYQ) and exemplary answer scripts of toppers. This resource is invaluable for exam preparation, allowing individuals to familiarize themselves with the exam format, gain insights into scoring techniques, and enhance their performance in assessments.



- **Free and Unlimited Resources:** Members enjoy the benefit of accessing an array of educational resources without any cost restrictions. Whether its study materials, teaching aids, or assessment tools, the group offers an abundance of resources tailored to individual needs. This accessibility ensures that educators and students have ample support in their academic endeavors without financial constraints.
- **Instant Access to Educational Content:** SOE WhatsApp groups are a platform where teachers can access a wide range of educational content instantly. This includes study materials, notes, sample papers, reference materials, and relevant links shared by group members and moderators.
- **Timely Updates and Reminders:** SOE WhatsApp groups serve as a source of timely updates and reminders about important dates, exam schedules, syllabus changes, and academic events. Teachers can stay informed and well-prepared for upcoming assessments and activities.
- **Interactive Learning Environment:** Teachers can engage in discussions, ask questions, and seek clarifications within the group, creating an interactive learning environment. This fosters collaboration, peer learning, and knowledge sharing among group members, enhancing understanding and retention of concepts.
- **Access to Expert Guidance:** SOE WhatsApp groups are moderated by subject matter experts, teachers, or experienced educators can benefit from their guidance, expertise, and insights on various academic topics, exam strategies, and study techniques.

Join the School of Educators WhatsApp Group today and unlock a world of resources, support, and collaboration to take your teaching to new heights. To join, simply click on the group links provided below or send a message to +91-95208-77777 expressing your interest.

**Together, let's empower ourselves & Our Students and  
inspire the next generation of learners.**

**Best Regards,  
Team  
School of Educators**

# Join School of Educators WhatsApp Groups

You will get Pre- Board Papers PDF, Word file, PPT, Lesson Plan, Worksheet, practical tips and Viva questions, reference books, smart content, curriculum, syllabus, marking scheme, toppers answer scripts, revised exam pattern, revised syllabus, Blue Print etc. here . Join Your Subject / Class WhatsApp Group.

## Kindergarten to Class XII (For Teachers Only)



[Click Here to Join](#)

**Class 1**



[Click Here to Join](#)

**Class 2**



[Click Here to Join](#)

**Class 3**



[Click Here to Join](#)

**Class 4**



[Click Here to Join](#)

**Class 5**



[Click Here to Join](#)

**Class 6**



[Click Here to Join](#)

**Class 7**



[Click Here to Join](#)

**Class 8**



[Click Here to Join](#)

**Class 9**



[Click Here to Join](#)

**Class 10**



[Click Here to Join](#)

**Class 11 (Science)**



[Click Here to Join](#)

**Class 11 (Humanities)**



[Click Here to Join](#)

**Class 11 (Commerce)**



[Click Here to Join](#)

**Class 12 (Science)**



[Click Here to Join](#)

**Class 12 (Humanities)**



[Click Here to Join](#)

**Class 12 (Commerce)**



[Click Here to Join](#)

**Kindergarten**

# Subject Wise Secondary and Senior Secondary Groups (IX & X For Teachers Only)

## Secondary Groups (IX & X)



[Click Here to Join](#)

SST



[Click Here to Join](#)

Mathematics



[Click Here to Join](#)

Science



[Click Here to Join](#)

English



[Click Here to Join](#)

Hindi-A



[Click Here to Join](#)

IT Code-402



[Click Here to Join](#)

Hindi-B



[Click Here to Join](#)

Artificial Intelligence

## Senior Secondary Groups (XI & XII For Teachers Only)



[Click Here to Join](#)

Physics



[Click Here to Join](#)

Chemistry



[Click Here to Join](#)

English



[Click Here to Join](#)

Mathematics



[Click Here to Join](#)

Biology



[Click Here to Join](#)

Accountancy



[Click Here to Join](#)

Economics



[Click Here to Join](#)

BST



[Click Here to Join](#)

History



[Click Here to Join](#)

**Geography**



[Click Here to Join](#)

**Sociology**



[Click Here to Join](#)

**Hindi Elective**



[Click Here to Join](#)

**Hindi Core**



[Click Here to Join](#)

**Home Science**



[Click Here to Join](#)

**Sanskrit**



[Click Here to Join](#)

**Psychology**



[Click Here to Join](#)

**Political Science**



[Click Here to Join](#)

**Painting**



[Click Here to Join](#)

**Vocal Music**



[Click Here to Join](#)

**Comp. Science**



[Click Here to Join](#)

**IP**



[Click Here to Join](#)

**Physical Education**



[Click Here to Join](#)

**APP. Mathematics**



[Click Here to Join](#)

**Legal Studies**



[Click Here to Join](#)

**Entrepreneurship**



[Click Here to Join](#)

**French**



[Click Here to Join](#)

**IT**



[Click Here to Join](#)

**Artificial Intelligence**

## **Other Important Groups (For Teachers & Principal's)**



[Click Here to Join](#)

**Principal's Group**



[Click Here to Join](#)

**Teachers Jobs**



[Click Here to Join](#)

**IIT/NEET**

# Join School of Educators WhatsApp Groups

You will get Pre- Board Papers PDF, Word file, PPT, Lesson Plan, Worksheet, practical tips and Viva questions, reference books, smart content, curriculum, syllabus, marking scheme, toppers answer scripts, revised exam pattern, revised syllabus, Blue Print etc. here . Join Your Subject / Class WhatsApp Group.

## Kindergarten to Class XII (For Students Only)



[Click Here to Join](#)

**Class 1**



[Click Here to Join](#)

**Class 2**



[Click Here to Join](#)

**Class 3**



[Click Here to Join](#)

**Class 4**



[Click Here to Join](#)

**Class 5**



[Click Here to Join](#)

**Class 6**



[Click Here to Join](#)

**Class 7**



[Click Here to Join](#)

**Class 8**



[Click Here to Join](#)

**Class 9**



[Click Here to Join](#)

**Class 10**



[Click Here to Join](#)

**Class 11 (Science)**



[Click Here to Join](#)

**Class 11 (Humanities)**



[Click Here to Join](#)

**Class 11 (Commerce)**



[Click Here to Join](#)

**Class 12 (Science)**



[Click Here to Join](#)

**Class 12 (Humanities)**



[Click Here to Join](#)

**Class 12 (Commerce)**



[Click Here to Join](#)

**Artificial Intelligence  
(VI TO VIII)**

# Subject Wise Secondary and Senior Secondary Groups (IX & X For Students Only) Secondary Groups (IX & X)



[Click Here to Join](#)

SST



[Click Here to Join](#)

Mathematics



[Click Here to Join](#)

Science



[Click Here to Join](#)

English



[Click Here to Join](#)

Hindi



[Click Here to Join](#)

IT Code



[Click Here to Join](#)

Artificial Intelligence

## Senior Secondary Groups (XI & XII For Students Only)



[Click Here to Join](#)

Physics



[Click Here to Join](#)

Chemistry



[Click Here to Join](#)

English



[Click Here to Join](#)

Mathematics



[Click Here to Join](#)

Biology



[Click Here to Join](#)

Accountancy



[Click Here to Join](#)

Economics



[Click Here to Join](#)

BST



[Click Here to Join](#)

History





[Click Here to Join](#)

**Geography**



[Click Here to Join](#)

**Sociology**



[Click Here to Join](#)

**Hindi Elective**



[Click Here to Join](#)

**Hindi Core**



[Click Here to Join](#)

**Home Science**



[Click Here to Join](#)

**Sanskrit**



[Click Here to Join](#)

**Psychology**



[Click Here to Join](#)

**Political Science**



[Click Here to Join](#)

**Painting**



[Click Here to Join](#)

**Music**



[Click Here to Join](#)

**Comp. Science**



[Click Here to Join](#)

**IP**



[Click Here to Join](#)

**Physical Education**



[Click Here to Join](#)

**APP. Mathematics**



[Click Here to Join](#)

**Legal Studies**



[Click Here to Join](#)

**Entrepreneurship**



[Click Here to Join](#)

**French**



[Click Here to Join](#)

**IT**



[Click Here to Join](#)

**AI**



[Click Here to Join](#)

**IIT/NEET**



[Click Here to Join](#)

**CUET**

## Groups Rules & Regulations:

**To maximize the benefits of these WhatsApp groups, follow these guidelines:**

1. Share your valuable resources with the group.
2. Help your fellow educators by answering their queries.
3. Watch and engage with shared videos in the group.
4. Distribute WhatsApp group resources among your students.
5. Encourage your colleagues to join these groups.

### **Additional notes:**

1. Avoid posting messages between 9 PM and 7 AM.
2. After sharing resources with students, consider deleting outdated data if necessary.
3. It's a NO Nuisance groups, single nuisance and you will be removed.
  - No introductions.
  - No greetings or wish messages.
  - No personal chats or messages.
  - No spam. Or voice calls
  - Share and seek learning resources only.

**Please only share and request learning resources. For assistance, contact the helpline via WhatsApp: +91-95208-77777.**

# Join Premium WhatsApp Groups Ultimate Educational Resources!!

Join our premium groups and just Rs. 1000 and gain access to all our exclusive materials for the entire academic year. Whether you're a student in Class IX, X, XI, or XII, or a teacher for these grades, Artham Resources provides the ultimate tools to enhance learning. Pay now to delve into a world of premium educational content!

[Click here for more details](#)



**Click Here to Join**

**Class 9**



**Click Here to Join**

**Class 10**



**Click Here to Join**

**Class 11**



**Click Here to Join**

**Class 12**

📢 Don't Miss Out! Elevate your academic journey with top-notch study materials and secure your path to top scores! Revolutionize your study routine and reach your academic goals with our comprehensive resources. Join now and set yourself up for success! 🇧🇩🌟

**Best Wishes,**

**Team**

**School of Educators & Artham Resources**

# SKILL MODULES BEING OFFERED IN MIDDLE SCHOOL



Artificial Intelligence



Beauty & Wellness



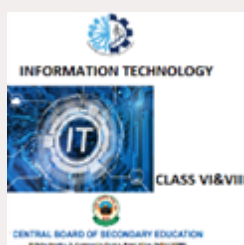
Design Thinking & Innovation



Financial Literacy



Handicrafts



Information Technology



Marketing/Commercial Application



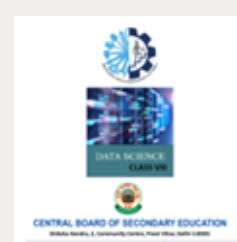
Mass Media - Being Media Literate



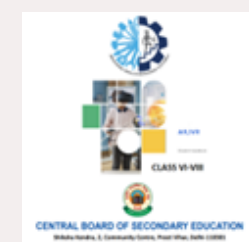
Travel & Tourism



Coding



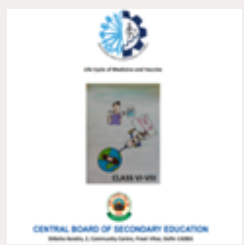
Data Science (Class VIII only)



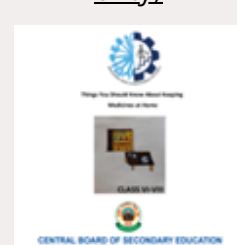
Augmented Reality / Virtual Reality



Digital Citizenship



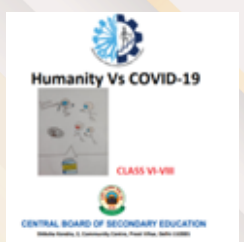
Life Cycle of Medicine & Vaccine



Things you should know about keeping Medicines at home



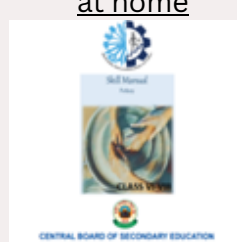
What to do when Doctor is not around



Humanity & Covid-19



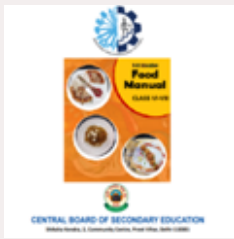
Blue Pottery



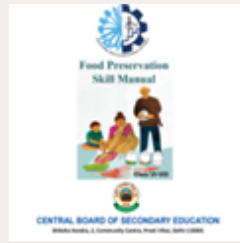
Pottery



Block Printing



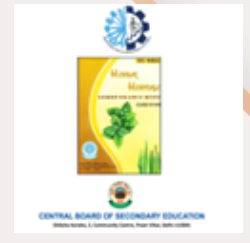
Food



Food Preservation



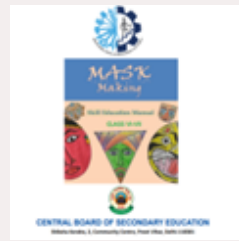
Baking



Herbal Heritage



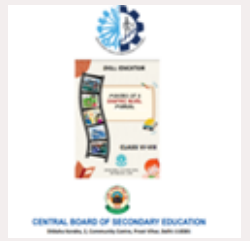
Khadi



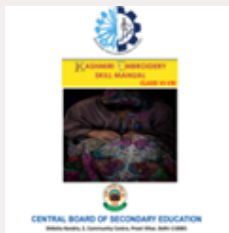
Mask Making



Mass Media



Making of a Graphic Novel



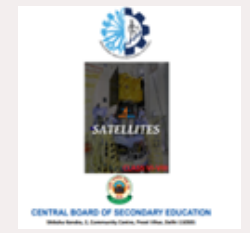
Kashmiri Embroidery



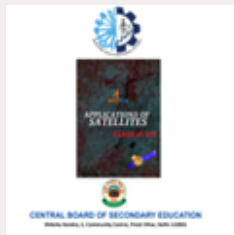
Embroidery



Rockets



Satellites



Application of Satellites



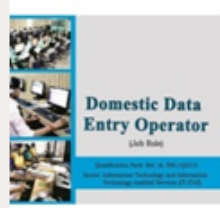
Photography



# SKILL SUBJECTS AT SECONDARY LEVEL (CLASSES IX – X)



Retail



Information Technology



Security



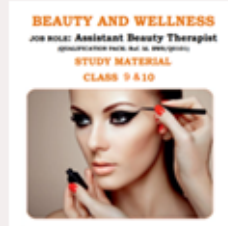
Automotive



Introduction To Financial Markets



Introduction To Tourism



Beauty & Wellness



Agriculture



Food Production



Front Office Operations



Banking & Insurance



Marketing & Sales



Health Care



Apparel



Multi Media



Multi Skill Foundation Course



Artificial Intelligence



Physical Activity Trainer



Data Science



Electronics & Hardware (NEW)



Foundation Skills For Sciences (Pharmaceutical & Biotechnology)(NEW)



Design Thinking & Innovation (NEW)



# SKILL SUBJECTS AT SR. SEC. LEVEL (CLASSES XI – XII)



Retail



Information Technology



Web Application



Automotive



Financial Markets Management



Tourism



Beauty & Wellness



Agriculture



Food Production



Front Office Operations



Banking



Marketing



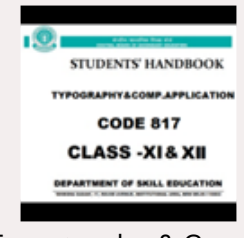
Health Care



Insurance



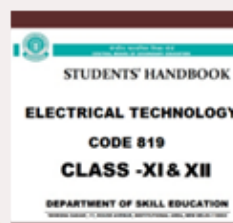
Horticulture



Typography & Comp.  
Application



Geospatial Technology



Electrical Technology



Electronic Technology



Multi-Media



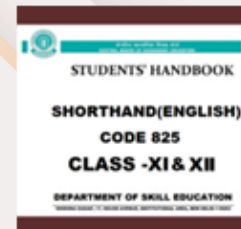
Taxation



Cost Accounting



Office Procedures & Practices



Shorthand (English)



Shorthand (Hindi)



Air-Conditioning & Refrigeration



Medical Diagnostics



Textile Design



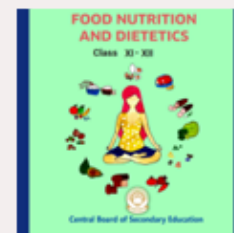
Design



Salesmanship



Business Administration



Food Nutrition & Dietetics



Mass Media Studies



Library & Information Science



Fashion Studies



Applied Mathematics



Yoga



Early Childhood Care & Education



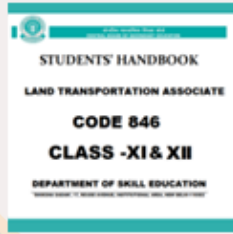
Artificial Intelligence



Data Science



Physical Activity Trainer(new)



Land Transportation Associate (NEW)



Electronics & Hardware (NEW)



Design Thinking & Innovation (NEW)